# A survey for the Southern Myotis *Myotis macropus* (Vespertilionidae) and other bat species in River Red Gum *Eucalyptus camaldulensis* forests of the Murray River, New South Wales

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## ABSTRACT

During March 1997 we surveyed for *Myotis macropus* at 18 water bodies along the Murray River in River Red Gum *Eucalyptus camaldulensis* forests in the Millewa and Perricoota/Koondrook State Forests, using Anabat II detectors and harp-traps. Although no *M. macropus* were caught, they were recorded by Anabat detectors at two sites, one at Moira Lakes Flora Reserve and one on the Murray River at Barmah Bridge. These records were within 7 km of each other and near a previous record on the Murray River (Hoye 1995). Despite the rarity of *M. macropus* in these forests, high levels of microchiropteran activity from 12 other taxa were recorded. On average, one bat pass was recorded for every minute of sampling in the first hour after dark. Eight taxa (*Vespadelus vulturnus, V. regulus, V. darlingtoni, Chalinolobus gouldii, C. morio, Mormopterus* sp. and *Tadarida australis*) were recorded at more than 70% of sites, while four species (*Scotorepens balstoni, Nyctophilus gouldi, Nyctophilus geoffroyi* and *Myotis macropus*) were recorded from less than 40% of sites. River Red Gum forests are particularly important to bats as a mesic habitat in a predominantly semi-arid landscape. Further studies on *M. macropus* are required to determine the reason for its rarity in an area with abundant surface water.

Key words: *Myotis macropus*, River Red Gum, Murray River, Bats.

## INTRODUCTION

The Southern Myotis *Myotis macropus* is listed on the New South Wales *Threatened Species Act 1995* by its previous name *M. adversus*. It is one of only two Australian species of fishing bat. It forages over pools of water in small streams, rivers and lakes, using its large feet to trawl along water surfaces for aquatic insects and small fish (Dwyer 1970; Thompson and Fenton 1982; Robson 1984). It is distributed along the east coast of Australia from south-east Queensland to Victoria and South Australia. Little is known of its status in inland water systems. It was recorded west of the divide in the 1970s from a billabong at Boomanoomana State Forest, near Mulwala and the Murray River (B. Gall, unpubl. data). Jansen (1987) captured five *M. macropus* in monofilament mistnets set on a small creek near the Murray River in South Australia and suggested that the species may occur along the full length of the river system. A single capture of *M. macropus* was recorded by Lumsden *et al.* (1995) in River Red Gum forest from 133 survey sites in a variety of vegetation types on the northern plains region of Victoria. More recently, Hoye (1995) surveyed bats for State Forests of NSW (Western Region) and caught a single individual on the Murrumbidgee River near Hay. He also recorded their ultrasonic pulses on the Murray River, adjacent to the extensive Millewa/Barmah River Red Gum forests, near Deniliquin. None of these broader bat surveys targeted *M. macropus* by concentrating survey effort on water bodies. Lumsden *et al.* (1995) suggested that the species may prove to be more widespread if this approach were followed.

This survey was undertaken to clarify the status of *M. macropus* in River Red Gum forests of the Murray River near Deniliquin. We took a broad survey approach to include a number of State Forests, but specifically targeted a range of water bodies from large rivers to ephemeral wetlands. The general aim was to determine the distribution of *M. macropus* in State Forests near Deniliquin and to investigate whether *M. macropus* was more active over certain kinds of water bodies. We also intended to document the activity levels and distribution of at least 12 other microchiropteran species that could be expected to occur in this area as few bat surveys have been undertaken in western New South Wales.

## METHODS

### *Study area*

Surveys were undertaken in forest along the Murray River, its anabranches and adjacent rivers. Sites were located in State Forests of the Millewa and Koondrook/Perricoota area, about 40 to 50 km SSW of Deniliquin, New South Wales (Fig. 1). Most of the extensive forests in this area are dominated by a single species — the River Red Gum *Eucalyptus camaldulensis*. In the past, periodic flooding during winter-spring was an integral feature of the River Red Gum forests along the Murray, however, regulation of river flows has considerably altered this pattern (Bacon *et al.* 1993a; Donovan 1997). Flat floodplains dominate the area with occasional sandy ridges where White Cypress Pine *Callitris glaucophylla* replaces *E . camaldulensis*. Surface water is plentiful throughout and occurs either in the form of large flowing rivers (e.g., Murray River, Edward River, Gulpa Creek), irregularly flowing smaller creeks (e.g., Toupna Creek, Warwick Creek), permanent billabongs or ephemeral wetlands. Large water bodies, such as Moira Lake, are also present. The Millewa group of forests has been used for forestry activities for over a century. When the use of riverboats began in the 1850s, areas adjacent to the Murray River were mostly clear-felled for timber (Donovan 1997). Regulation of the timber industry and silvicultural treatment began in the 1890s, and both have undergone many revisions since that time (Donovan 1997). Despite the long history of logging, large individuals of *E. camaldulensis* with abundant hollows remain relatively common. The understorey is characterized by the absence of a shrub layer and a dominance of grasses and sedges (Bacon *et al.* 1993b).

### *Bat survey*

Bats were surveyed at 18 sites in State Forests during the dark phase of the moon from 4 to 9 March, 1997. Each site was located at a water-body within River Red Gum forest. Large rivers (4 sites), flowing creeks (2), small intermittently-flowing creeks (3), permanent billabongs (4), ephemeral wetlands (3) and lakes (2) were surveyed. At each site one harp-trap and one Anabat II (Titley Electronics) ultrasonic detector were deployed for two consecutive nights. Traps were set directly over water for smaller water bodies and adjacent to water for larger ones. All detectors were pointed over water at an angle where bats flying near to the water's surface would be recorded. Six sites were trapped and detected each night. Two additional harp-traps were used to supplement trapping effort at one or two sites each night, giving 46 trap-nights as the total trapping effort for the survey. Two of the 18 sites could not be trapped because they were frequented by the public. On one night each, we used three additional survey techniques — mist-netting, trip-lining and hand-held ultrasonic detection. Our observations of hand-released *M. macropus* indicate that their ultrasonic calls can be detected by the Anabat system for at least 20 m.

Anabat detectors were linked to a Delay Switch (Titley Electronics) to allow remote monitoring of sites (Law *et al.* 1998). Because of high bat activity levels Delay Switches were only able to extend the 45 min. cassette length to an average of 1.9 h of sampling (maximum = 7.5 h). Thus we typically sampled between 2030 and 2230 h (Eastern Summer Time), covering the period when Jansen (1987) caught *M. macropus* on the Murray River in South Australia (2100–2130 h) and their emergence times in other parts of New South Wales (B. Law and J. Anderson, pers. obs.). We used the first hour after dark (2030–2130 h), the period of greatest activity for most bat species (Law *et al.* 1998), as our base-line for comparisons of activity levels. This was calculated as the mean of the two nights sampling at each site.

A bat pass was defined as a sequence of three or more pulses (see Law *et al.* 1998 for more details). Bat passes were identified using zero-crossing analysis and Anabat Software (Version 5), by comparing call traits with reference calls recorded from captured bats released during the survey. For some species captured in low numbers or not at all, the authors' reference calls from the south-west slopes, Narrandera and other parts of New South Wales were used when making identifications. Some species had calls that were difficult to distinguish using Anabat software. No attempt was made to distinguish *Nyctophilus gouldi* from *N. geoffroyi* on the basis of calls as they are usually considered indistinguishable. Some overlap occurred in the calls of *Vespadelus vulturnus* and *Chalinolobus morio* plus *Mormopterus* species and *Chalinolobus gouldii*. Only calls of high quality could distinguish these species. We did not confidently distinguish the calls of at least three species of *Mormopterus* that could be expected from this area as only one species was captured (*M. planiceps* long penis = species 1 in Adams *et al.* 1988). However, comparisons of reference calls of *M. planiceps* short penis (species 3 in Adams *et al.* 1988), recorded by us at Narrandera, allowed us to confirm that both species were present in the Deniliquin forests. In general, calls of poor quality or short duration were grouped as unidentified bat passes and incorporated into measures of total bat activity. The presence of feeding attempts (feeding buzz) was assessed by listening to replays of calls and inspecting call characteristics such as increased pulse rates and an increase in the terminal frequency of calls (Jones and Corben 1993). A feeding rate was

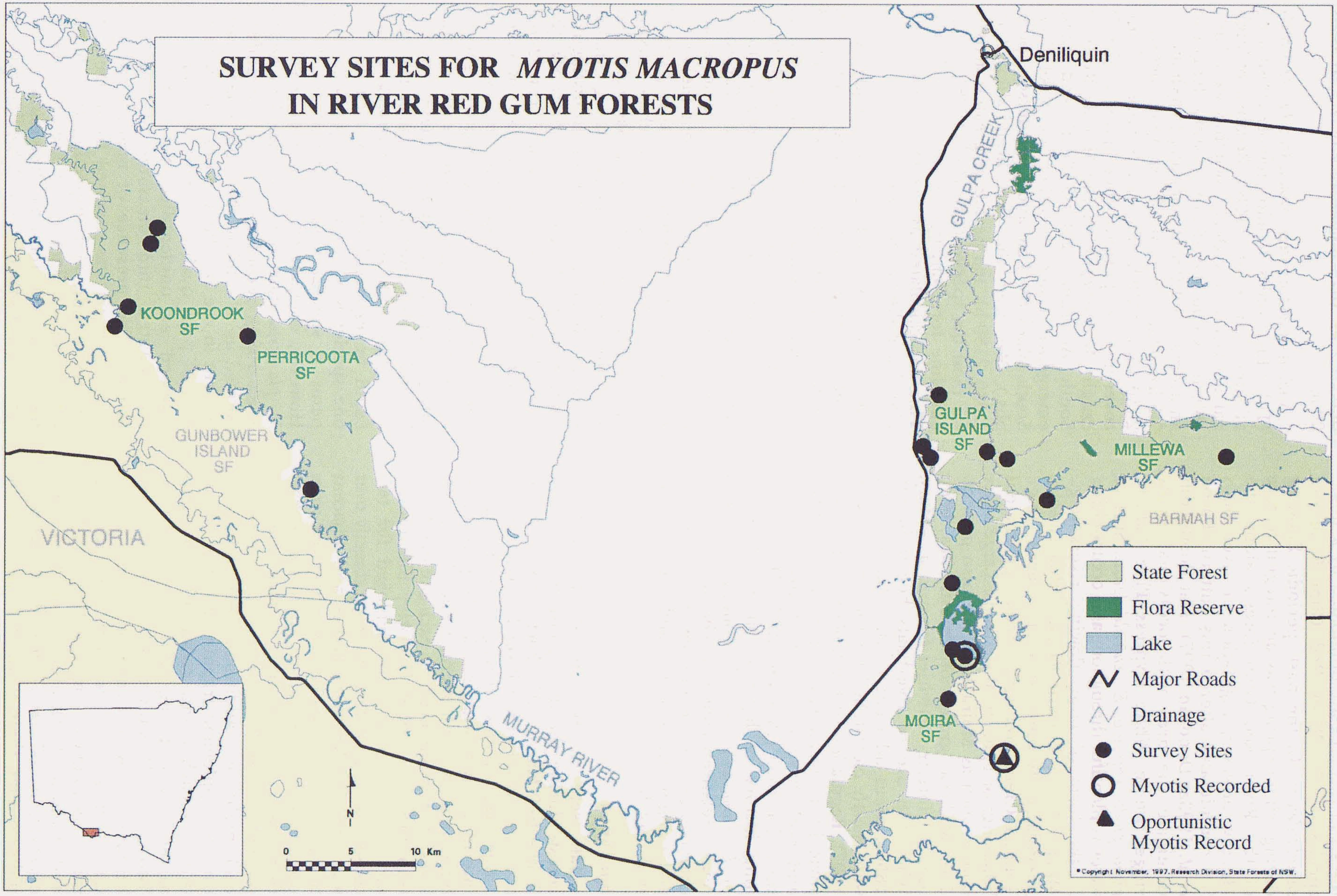
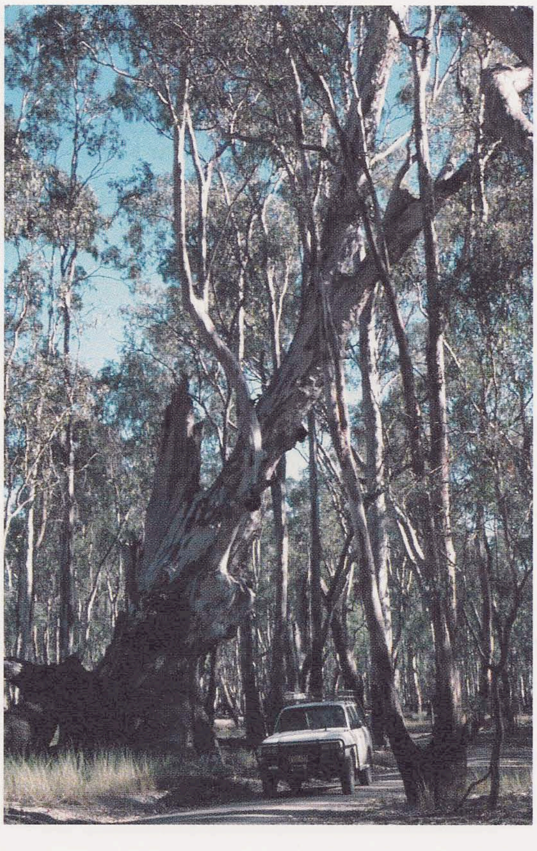


*Fig. 1.* Map of the study area, showing State Forests and survey sites for *Myotis macropus*. Each survey site comprised 1–3 harp-traps and one Anabat detector. All sites were located on water bodies. White areas of the map have been predominantly cleared of native vegetation for agriculture.



*Top left:* The River Murray with fringing River Red Gums in Perricoota State Forest, New South Wales.

*Top right:* Moira Lakes Flora Reserve where a single pass of *Myotis macropus* was recorded.

*Centre left:* J. Anderson setting-up a remotely deployed Anabat detector at an ephemeral wetland ("Deadwood Swamp").

*Centre right:* Gulpa Creek in Millewa State Forest provides potential foraging habitat for *M. macropus*, but none was trapped or detected.

*Left:* Although heavily logged over the past 100 years, some large specimens of *E. camaldulensis*, with an abundance of hollows, remain.

(Photos by B. Law.)

calculated as the number of feeding buzzes divided by total passes for that site.

*M. macropus* usually roosts in caves, mines or beneath bridges (Richards 1995). As there were no caves or mines present in this area, we searched bridges for the presence of roosting bats.

## RESULTS

### *Records of* **Myotis macropus**

*Myotis macropus* was infrequently recorded in the River Red Gum forests near Deniliquin. No *M. macropus* were trapped during the 46 trap-nights spent at the 18 potentially suitable water bodies sampled. Anabat detectors recorded a single pass at just one of these sites — Moira Lakes Flora Reserve (Fig. 1 and Table 1). One opportunistic ultrasonic detection beneath the large Barmah Bridge on the Murray River recorded *M. macropus* in flight. This was 7 km south of the Moira Lakes record (Fig. 1).

No disused mines or caves are known locally in the Millewa and Pericootta/Koondrook areas (J. Morton, SFNSW, pers. comm.). However, bridges over water ways are relatively common. These ranged from small, wooden-slat type bridges to large bridges constructed from logs. New concrete bridges were also searched and these were both small and large (e.g., accessible parts of Barmah Bridge over the Murray River). No signs of roosting bats were recorded beneath accessible parts of any of the 15 bridges that were searched, although bridges on the Victorian side of the border were not searched.

### *Records of other Microchiropterans*

Twelve taxa of bats were recorded from the 18 water bodies sampled. A total of 80 bats from eight species were trapped (Table 1) at the low rate of 1.7 per trap-night. This probably reflects the lack of good flyways for trapping in the open River Red Gum forests as Anabat detectors recorded high levels of activity. A total of 1 431 passes were recorded from 11 taxa (Table 1). In the first hour after dark, this translates to 1.3 bat passes per minute. Many calls were of a relatively poor quality, with 44% not being identified to species level. This possibly reflects the open nature of the detection sites and the fact that many bats were probably not close to the Anabat detector when they were recorded. Nine per cent of passes were feeding attempts, with a feeding attempt occurring every 8 minutes (Table 1).

Five feeding buzzes in the first hour after dark was the most frequently recorded foraging level at a site (Fig. 2). However, both activity and the number of feeding buzzes varied considerably between sites and the two were not correlated ($r = -0.11$, $P > 0.1$) across the 18 survey sites. For example, the number of passes in the first hour after dark ranged from 245 at Gulpa Creek (feeding rate = 0.02; i.e., a feeding attempt for every 50 passes) to 23 passes at the ephemeral wetland at Porter's Plain (feeding rate = 0.58). Zero feeding attempts in the first hour after dark were recorded at two sites (unnamed Lagoon near Gulpa Creek and Myloc Creek), both of which had close to average levels of activity. The greatest number of feeding buzzes (23) was recorded at Toupna Creek, where activity was just below average (56 passes).

Although any comparisons of activity between species must be treated cautiously because of different call intensities, *Vespadelus vulturnus* and *V. regulus* had the highest activity levels

*Table 1.* Total number of bats caught in harp-traps placed adjacent to water bodies and mean number of passes and feeding buzzes recorded per site in the first hour after dark in River Red Gum forests near Deniliquin.

| Bat species | Number trapped | Mean passes | Mean feeding buzzes |
|---|---|---|---|
| *Vespadelus vulturnus* | 28 | 12.7 | 0.5 |
| *Vespadelus regulus* | 10 | 12.0 | 1.1 |
| *Chalinolobus morio* | 3 | 6.4 | 0.6 |
| *Chalinolobus gouldii* | 16 | 6.2 | 0.2 |
| *Nyctophilus* sp. | — | 4.8 | 0.8 |
| *Mormopterus* sp. | — | 3.5 | 0.1 |
| *Mormopterus planiceps* (lp) | 2 | — | — |
| *Mormopterus planiceps* (sp) | 0 | — | — |
| Nyctinomus australis | 0 | 2.4 | 0 |
| *Vespadelus darlingtoni* | 7 | 1 | 0.1 |
| *Scotorepens balstoni* | 0 | 0.9 | 0 |
| *Myotis macropus* | 0 | 0.1 | 0 |
| *Nyctophilus gouldi* | 11 | — | — |
| *Nyctophilus geoffroyi* | 3 | — | — |
| All Species | 80 | 79.5 | 7.1 |

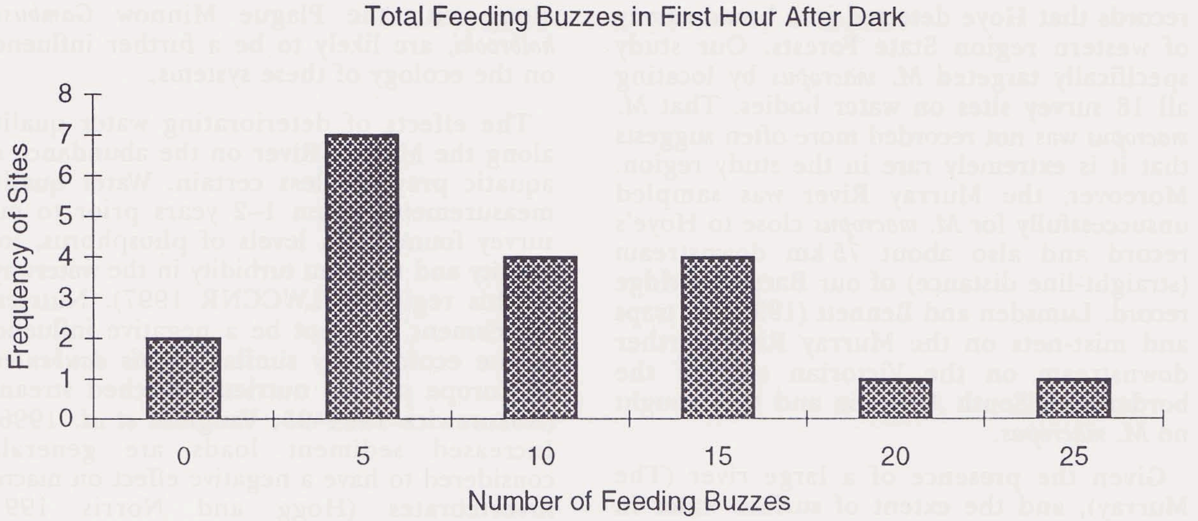


*Fig. 2.* Histogram of feeding buzzes (in groups of 5) in the first hour after dark at the 18 survey sites. Most sites had five feeding buzzes recorded in the first hour after dark.

among the species recorded. *V. vulturnus* was the most frequently trapped and recorded species and was found at the greatest number of sites (94%) (Tables 1 and 2). *Mormopterus* (comprising up to three species) was recorded at 100% of detector sites, although activity levels were not high for this taxa (Tables 1 and 2). Eight taxa (*V. vulturnus, V. regulus, V. darlingtoni, Chalinolobus gouldii, C. morio, Mormopterus* and *Nyctinomus australis*) were recorded at more than 70% of sites, while four species (*Scotorepens balstoni, Nyctophilus gouldi, N. geoffroyi* and *Myotis macropus*) were recorded from less than 40% of sites (Table 2).

To investigate whether bat activity varied between different types of water bodies we separated the 18 sampling sites into four categories. These were flowing rivers (six sites), billabongs and small intermittently-flowing creeks (seven sites), ephemeral wetlands (three sites) and lakes (two sites). Kruskal-Wallis Tests found no differences between these different water bodies for activity levels of individual species, total bat activity, total feeding activity or species richness (P's > 0.1). A similar analysis of differences in the feeding activity of individual species was not possible because of low sample sizes. This resulted from a lack of feeding buzzes from a relatively large sub-set of sites for each species.

## DISCUSSION

### *Status of* Myotis macropus *in River Red Gum forests near Deniliquin*

The current survey recorded the presence of *M. macropus* at just two locations. These were on the Murray River at Barmah Bridge and the nearby Moira Lake. These records were within 7 km of each other. A previous record of *M. macropus* in State Forests of this region was also on the Murray River (G. Hoye, unpubl. data), about mid-way between our two recent records. This was one of only two

*Table 2.* Percentage occurrence of bat species from trapping (n = 16 sites) and detection records (n = 18 sites) in River Red Gum forest.

| Bat species | Percentage of sites (trapping) | Percentage of sites (detecting) | % Sites (total — both methods) |
|---|---|---|---|
| *Vespadelus vulturnus* | 50 | 94 | 94 |
| *Vespadelus regulus* | 31 | 78 | 88 |
| *Chalinolobus gouldii* | 13 | 89 | 89 |
| *Mormopterus planiceps* (lp) | 13 | | |
| *Chalinolobus morio* | 6 | 83 | 83 |
| *Vespadelus darlingtoni* | 25 | 77 | 77 |
| *Nyctinomus australis* | 0 | 77 | 77 |
| *Mormopterus* sp. | | 100 | — |
| *Nyctophilus* sp. | — | 44 | 44 |
| *Scotorepens balstoni* | 0 | 44 | 44 |
| *Nyctophilus gouldi* | 31 | — | — |
| *Nyctophilus geoffroyi* | 25 | — | — |
| *Myotis macropus* | 0 | 6 | 6 |

records that Hoye detected in a broad survey of western region State Forests. Our study specifically targeted *M. macropus* by locating all 18 survey sites on water bodies. That *M. macropus* was not recorded more often suggests that it is extremely rare in the study region. Moreover, the Murray River was sampled unsuccessfully for *M. macropus* close to Hoye's record and also about 75 km downstream (straight-line distance) of our Barmah Bridge record. Lumsden and Bennett (1995) set traps and mist-nets on the Murray River further downstream on the Victorian side of the border with South Australia and they caught no *M. macropus*.

Given the presence of a large river (The Murray), and the extent of surface water in surrounding forests, why was *M. macropus* so rarely recorded? There is a number of possible explanations. First, Anabat detectors probably under sample *M. macropus* in areas where water bodies are large as call sequences of *M. macropus* are mostly detected within 20 m of the bat. This effect would be most pronounced over lakes (Moira Lake) and large Rivers (Murray River). Most of the remaining sampled water bodies, however, were less than 30 m wide, suggesting that detection range was not a significant problem for most sites in this survey.

A low availability of the aquatic prey of *M. macropus* is one possible reason for the bat's rarity. Although the overall diversity of macroinvertebrates in the Murray River is high, except for sites immediately downstream of dams and sites in South Australia (Bennison and Suter 1990), reductions in prey abundance may have resulted from changes to water-flow regimes and/or deteriorating water quality (Briggs *et al.* 1998). The Murray River now experiences fewer flood events, with a shift from winter to summer flooding (Bacon *et al.* 1993b). Drying and subsequent flooding increases the number of invertebrates, particularly chironomids (Maher and Carpenter 1984; Crome 1986), a known food of *M. macropus* on the Murray River (Jansen 1987). In contrast, permanent flooding supports relatively few invertebrates (Maher and Carpenter 1984), possibly because of competition from fish (Neckles *et al.* 1990). The influence of these different flow-regimes on *M. macropus* remains speculative as we sampled a variety of water ways from permanent billabongs and rivers to intermittently flowing creeks and ephemeral wetlands. *M. macropus* was not recorded at most water bodies. Previous surveys of fish at some of our sites had found low numbers of natives compared to other inland rivers, with Carp *Cyprinus carpio* dominating the captures (Gehrke *et al.* 1995). These introduced fish, along with the Plague Minnow *Gambusia holbrooki,* are likely to be a further influence on the ecology of these systems.

The effects of deteriorating water quality along the Murray River on the abundance of aquatic prey are less certain. Water quality measurements taken 1–2 years prior to our survey found high levels of phosphorus, low salinity and medium turbidity in the waterways of this region (DLWCCNR 1997). Nutrient enrichment may not be a negative influence as the ecologically similar *Myotis daubentoni* of Europe prefers nutrient-enriched streams (Kokurewicz 1994–95; Vaughan *et al.* 1996). Increased sediment loads are generally considered to have a negative effect on macroinvertebrates (Hogg and Norris 1991; Metzeling *et al.* 1995). The medium turbidity levels in the Murray River (DLWCCNR 1997), are mostly due to the presence of fine clay particles that tend to remain in suspension (Shafron *et al.* 1990).

A lack of roost sites may be a further contributor to the rarity of *M. macropus*. Typical roosts occur in caves, mines or beneath bridges (Richards 1995). Caves and mines were absent and most bridges in the area may be unsuitable because they would experience regular flooding. It is interesting to note that limestone cliffs and caves are a feature of the locality where the species was caught on the Murray River in South Australia (Jansen 1987). Roosting sites in this area have been described as groups of about 10 bats in holes within a limestone rock overhang, 2 metres above the water level (Kirkley 1996). The dependence on cave and bridge roosts has been questioned recently, with the finding that *M. macropus* roosts in tree hollows in Victoria (Schedvin, pers. comm. in Lumsden and Menkhorst 1995; C. Caddle, pers. comm. 1998) and within nests of Fairy Martins *Hirundo ariel* in road culverts in eastern Australia (Schulz 1998). It is not known whether tree roosts would be limiting in River Red Gum forests given that *E. camaldulensis* forms abundant hollows. A study of tree-hollow availability found that hollows were abundant in nearby Victorian State Forest that contain River Red Gums, in comparison to forests dominated by other species (Bennett *et al.* 1994). Habitat trees with abundant hollows occur at a frequency of about 3 to 10 trees/ha at Millewa, while >10 recruit habitat trees (characterized by the presence of dead/broken limbs in the crown) occur per ha (D. Leslie, SFNSW, pers. comm.).

Research is required to investigate which factors are responsible for the rarity of *M. macropus* in an area where surface water is super-abundant (Caughley 1994) and what management actions should be taken to ensure the viability of local populations.

### *Other Microchiropteran bats of River Red Gum forests*

Mean total bat activity in the first hour after dark (80 passes) was high and identical to that recorded over water on the south-west slopes of New South Wales (80 passes — Law *et al.* 1998). In the south-west slopes survey, water was relatively sparse and therefore bat activity was probably concentrated. In contrast, surface water was freely available and common in the River Red Gum forests during this study. The level of feeding activity was also remarkably similar between these two areas, with a feeding pass every 8 min in both River Red Gum forests and over water on the south-west slopes (Law *et al.* 1998).

That the activity of individual species was not found to vary between different types of water bodies in River Red Gum forests is perhaps not surprising, as although flow rates and aspects of water quality would have differed, each site consisted of a large open space over water surrounded by forest dominated by a single tree species. Different species of bats are more likely to respond to differences in the structural composition of forests or differences in the availability of roosts (see Law 1996).

Lumsden and Bennett's (1995) survey of semi-arid northwestern Victoria found that the greatest capture rate of bats among four sampled vegetation types was in riverine woodland dominated by *E. camaldulensis*. Greater captures of most species occurred in this vegetation type, except for *N. geoffroyi*, which was more commonly caught in Mallee Shrubland. *N. gouldi* was not caught in River Red Gum forest by Lumsden and Bennett (1995), but it was trapped in our survey, suggesting that the Millewa group of forests may be close to the western edge of *N. gouldi's* range. *S. balstoni* and species of *Mormopterus* were recorded in low numbers by Lumsden and Bennett (1995) and Lumsden *et al.* (1995). The few records of *S. balstoni* from our study indicate that this bat is uncommon in riverine forests. However, we recorded *Mormopterus* at 100% of our sites. This difference from the trapping (Lumsden and Bennett 1995; Lumsden *et al.* 1995) probably reflects the more effective detection of *Mormopterus* using ultrasonic detectors compared to harp-traps as the species flies above trap height and/or preferentially feeds in open areas. We did not record the presence of two other species of semi-arid adapted bats, *N. timoriensis* and *V. baverstocki*, adding support to the rarity of the former (Lumsden 1994) and the preference of the latter for drier, open woodlands (Lumsden and Bennett 1995). The presence of mesic-adapted species, such as *N. gouldi* and *V. regulus*, indicates the importance River Red Gum forests for supporting populations of primarily temperate bat species in a semi-arid environment (see also Lumsden and Bennett 1995).

It is interesting to note that the characteristic frequency of *V. regulus* calls in this study were consistently close to 56 KHz, about 14 KHz higher than that recorded on the south-west slopes and south-east New South Wales (B. Law, pers. obs.). A specimen lodged with the Australian Museum was identified as *V. regulus* (H. Parnaby, pers. comm.). While these unusual calls may simply reflect geographic variation in call frequency, the possibility that an undescribed species exists in riverine forest in western New South Wales cannot be excluded.

Given the high level of foraging activity, bats must be considered a major component of the insectivore community of River Red Gum forests. As a result, the requirements of bats need to be carefully considered in forest management practices, particularly as these forests are considered to have levels of insect herbivory in the high range for *Eucalyptus* species (Stone and Bacon 1994).

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